Surface Clutter Due to Antenna Sidelobes for Spaceborne Atmospheric Radar

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Abstract

A spaceborne atmospheric radar must be designed to provide a detectable signal from distant, weakly reflecting atmospheric targets. This requires maximizing the received signal while minimizing noise and interfering signals. For downward looking systems a particular concern is interfering, or clutter, signals from the earth's surface. Since surface scattering can be much stronger than scattering from atmospheric targets, a quantitative analysis of clutter must be made. Previous analyses of this problem have dealt with clutter due to the same pulse as that illuminating the atmosphere. This is of concern when the antenna is scanned off nadir. However, a more complete analysis should take into account other radar pulses as well. In general, the radar will simultaneously receive echoes from all targets which differ in range by an integer multiple of c/2PRF, where c is the speed of light. This is just the range ambiguity problem common to all radars. In this problem these ambiguities come from annuli lying on the earth's surface, weighted by the antenna pattern. A complete treatment of surface clutter due to antenna sidelobes is presented here. It includes return from all such annuli, due both to the current pulse and previous pulses. It also takes antenna scanning into account and includes interference from pulses transmitted after the pulse illuminating the atmosphere. Finally, the analysis presented here includes the effects of Doppler shifting and finite receiver bandwidth.

The theory is evaluated for several radar systems and comparisons with data are shown. Of particular interest is application to the Cloud Profiling Radar (CPR) on the proposed CloudSat Mission. It is shown that an antenna with low sidelobes is needed. It is also shown that the antenna sidelobe requirements can be relaxed by applying frequency diversity. In this approach the receiver tracks the frequency used to illuminate the atmosphere; clutter at other frequencies is rejected, substantially reducing clutter. This approach will be implemented on CPR.